DOCUMENT RESUME

ED 112 086 CE 004 852

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TITLE	Soils and Foundations: A Syllabus.
INSTITUTION	Rutgers, The State Univ., New Brunswick, N.J. Curriculum Lab.
SPONS AGENCY	New Jersey State Dept. of Education, Trenton. Div. of Vocational Education.
PUB DATE	Jan 74
NOTE	49p.
EDRS PRICE	MF-$0.76 HC-$1.95 Plus Postage
DESCRIPTORS	*Civil Engineering; *Course Content; Curriculum Guides; Learning Activities; Post Secondary Education; *Soil Science; *Teaching Guides; Teaching Methods; Unit Plan

ABSTRACT

The teaching guide and course outline for a 12-week course in soils and foundations is designed to help student technicians in a two-year associate degree civil engineering technology program to obtain entry level employment as highway engineering aides, soil testing technicians, soil mappers, or construction inspectors. The seven teaching units are: an introduction, field investigation and sampling, characteristics and classification of soils, improvement of soils, foundations, pavements and subgrades, and retaining walls. A topical outline, behavioral objectives for each teaching unit, employment objectives, a time distribution schedule, methodology with reference materials on which the units are based (texts, periodicals, audio-visuals, and equipment), student activities, assignment sheets (lecture and laboratory), and methods of evaluating progress are included. Seven laboratory experiments dealing with equipment and procedure familiarization for soil testing, density of soils--sand cone method, grain-size analysis of soils, moisture-density relations of soils, moisture content of soil, unconfined compressive strength of cohesive soil, and liquid limit of soils are scheduled in relation to the unit content. Standard designation, purpose, objectives, size of laboratory group, equipment, references, and procedures for each are described. Appended are a sample lesson plan, completion test, true-false test, and quiz. (MS)

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ED112086

SOILS AND FOUNDATIONS

A SYLLABUS

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State of New Jersey
Department of Education
Division of Vocational Education

SOILS AND FOUNDATIONS

A Syllabus

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January 1974

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CURRICULUM LABORATORY
RUTGERS – THE STATE UNIVERSITY
BUILDING 4103 – KILMER CAMPUS
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0.00 ABSTRACT

This syllabus presents in behavioral-objective format an instructor's teaching guide and course outline for a twelve-week, one-quarter (5 quarter hour credit) course titled "Soils and Foundations."

The course is the only one on this subject taken by the student technicians in a two-year Associate Degree Civil Engineering Technology program. Therefore it is presented as a course of fundamentals with emphasis on the basic understanding of each subject area, the reason why things are done, and how they are done. There are outlines for seven laboratory tests (experiments) to afford the students opportunities to perform actual job condition tests.

Through this laboratory work, the technician applies the theory of soils in a practical observable behavioral objective manner.

The syllabus includes a topical outline, behavioral objectives for each teaching unit, employment objectives, a time distribution schedule, methodology with reference materials (texts, periodicals, autio-visuals, and equipment), student activities, assignment sheets (lecture and laboratory), methods of evaluating progress, and a sample lesson plan.

This guide reduces engineering theory to a practical application package for civil technology; and it is intended to be a comprehensive teaching aid and student study guide for a technician's soils and foundations course.

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1.00 SUMMARY

This instructor's teaching outline was written as a comprehensive behavioral-objective syllabus for a course in soils and foundations. The twelve-week, five-quarter-hours credit course is for students in a two-year Associate Degree Civil Technology program.

At the conclusion of this course, the student will be able to communicate with persons knowledgeable in the fundamentals of soils and foundations by using the proper terms, the standard specifications for testing of soils, and by identifying the major soil and foundation theories.

In writing this guide for a condensed one-quarter course of a major engineering subject these limits were set:

1. The major emphasis would be to relate theory to application through "hands-on" laboratory experiences.
2. The theory would be presented in a basic mathematical format by using standard ASTM nomenclature and formulas.
3. All laboratory testing would utilize standard soil testing procedures and ASTM procedures.
4. The emphasis would be placed on the application of technical knowledge to the solution of industrial problems through sound practical decisions.
5. The measure of success of the course will be in providing the student with entry level knowledge and skill in soils and foundations.

Facts and Results

The eighty-contact hours are divided into 44 hours of lecture-demonstration-recitation, 33 hours of laboratory testing and a 3-hour final examination. Frequent "measures of success" for both the student

and the instructor are scheduled in the form of quizzes, tests, and examinations. Direct observation provides the instructor the opportunity to evaluate each student in laboratory testing skill development.

The seven teaching units are:

1.00 Introduction

2.00 Field Investigation and Sampling

3.00 Characteristics and Classification of Soils

4.00 Improvement of Soils

5.00 Foundations

6.00 Pavements and Subgrades

7.00 Retaining Walls

The related laboratory tests are:

1.00 General Laboratory Instructions

2.00 Density of Soil in Place

3.00 Grain Size Analysis

4.00 Moisture Density

5.00 Moisture Content

6.00 Unconfined Compressive Strength

7.00 Liquid Limit of Soils

Conclusion

This course, as part of the total training, will help students obtain entry level employment in such fields as highway engineering aide, soil testing technician, soil mapper and construction inspector.

2.00 INTRODUCTION

"Soils and Foundations" is a five-quarter-hour credit course in a two-year Associate Degree Civil Technology program. It consists of four, one-period lecture-recitation sessions per week and one, three-period laboratory session per week. The quarters are of twelve week duration with the last week reserved for final examination. This means there will be 44 hours of class contact in a lecture-recitation situation and 33 hours of laboratory activities.

This course is scheduled during the students' fifth quarter and is considered a related course for "Concrete Construction" which is scheduled during the sixth quarter. Since topics such as loads and pressures, foundations, retaining walls, and pavements are included, it is an excellent introduction to concrete construction practices and requirements.

"Soils and Foundations" enables the student to experience the transfer of learning from his previous science, mathematics, and related technical courses in studying the engineering properties and classifications of soils and the uses of soils as a construction material. The student develops skills in classifying soils through visual inspection, "mason jar" job testing, and standard laboratory testing in accordance with ASTM procedures and specifications. Major emphasis is placed on the meaning of the various properties of soils in solving engineering design and construction problems rather than the theoretical technical aspects. All theory is explained in the light of problem solving and practical application.

The student is expected to develop a working knowledge of standard laboratory and field testing equipment, testing methods, and procedures for gathering, recording and interpreting test data results.

2.1 Time Distribution

		Lecture Hours	Lab Test Number	Lab Hours	Total Unit Hrs.
	Lecture - Demonstrations				
Unit 1.00	Introduction	2	1.00	3	5
2.00	Field Investigation & Sampling	4	2.00	3	7
3.00	Characteristics & Classification of Soils	6	3.00	3	9
4.00	Improvements of Soils	4	4.00	3	7
5.00	Foundations	10	5.00	3	13
6.00	Pavements & Subgrades	4	6.00	3	7
7.00	Retaining Walls	10	7.00	3	13
	Total	40		21	61
	Laboratory				
1.00	General Laboratory Instructions			3	
2.00	Density of Soil in Place			3	
3.00	Grain Size Analysis			3	
4.00	Moisture Density			3	
5.00	Moisture Content			3	
6.00	Unconfined Compression Strength			3	
7.00	Liquid Limit of Soils			3	
	Total			21	

Evaluation

Quizzes	4
Tests	6
Mid Quarter Examination	3
Final Examination	3
Total	16

Recap of Time

Lecture	40 Hours	Lecture 11 weeks @ 4 hours =	44 Hours
Lab	21	Lab 11 weeks @ 3 hours =	33
Evaluation	16	Final Exam	3
Instructors' Time	3		
Total	80 Hours	Total	80 Hours

3.00 BEHAVIORAL OBJECTIVES

3.10 Career and Employment

Upon completion of this course as part of the integrated two-year Civil Technology program the student will have acquired knowledge and skills enabling him to qualify as an entry level employee in areas such as these:

1. *Highway Engineering Aide*- May collect and test soil samples, concrete and bituminous mixtures, and other highway materials to ascertain their physical characteristics -- load bearing and moisture capacity and plastic properties -- for use in construction of highways, air field runways, and similar structures.

2. *Soil Testing Technician*- Tests raw materials such as aggregate, limestone, and sand, for such qualitites as permeability, load bearing capacity or cohesiveness.

3. *Soil Mapper*- Studies soil structures origin and capabilities through field trips, laboratory examinations, and controlled experimentations. Develops and carries out programs of classifying and mapping soils according to established soil types.

4. *Construction Inspector*, such as ditch, highway, tunnel heading, airport paving, etc. - Observes work in progress to insure that procedures followed and materials used conform to specifications; prepares samples of unapproved materials for laboratory testing, logs pile driving, and verifies quantity and quality of excavations.

The course work is designed to provide training and understanding in the occupational requirements of those employees which are in demand by federal, state and city agencies and contractors.

As the employee (student) progresses from the entry job he should be capable of using judgement and making sound decisions as he performs his assigned duties.

3.20 Educational Behavioral Objectives

At the conclusion of this course, the student will acquire measurable behavioral change in both the cognitive and motor skills realm. The evaluation of these acquisitions will be through written quizzes, tests, examinations, and skill performance observations. The behavioral objectives of the teaching units are detailed in the following sections.

3.30 Unit Behavioral Objectives

Unit 1.00 Introduction to Soils and Foundations (2 hours)

At the conclusion of this unit, the student will be able to:

1. Identify the various ages of soil formations and write a description of the atmospheric conditions and their effect.
2. When given samples of various soils, through visual examination, classify the samples by major categories.
3. Use the proper terms and nomenclature in discussing the subject with someone knowledgeable in soils.
4. Label a soil profile, using accepted terminology.

Unit 2.00 Field Investigation and Sampling (4 hours)

When this unit is completed, the student will be able to:

1. Design a form for recording the necessary preliminary information for a soil investigation, when given the site location, building type, size, siting, and occupancy.
2. Identify the proper handling of samples, safeguards for their protection, and describe the importance of each.
3. Draw a free hand sketch of five methods of underground exploration, label the equipment, and list the usage of each method.
4. Indicate the number and location of required borings for all size building projects, when given site location, building type, size, siting, and occupancy.

Unit 3.00 Charcteristics and Classification of Soils (6 hours)

1. When given a list of soil properties, the student will be able to pick those that contribute to the load carrying capacity, and describe why.

2. When given a list of ten terms used in describing soil properties, the student will be able to properly define seven.

3. The student will be able to list the names of eight of the twelve preliminary soil classification types.

4. When given the raw data of a soil sieve analysis, the student will be able to plot a gradation curve and determine the effective particle size.

5. The student will be able to define the terms used in the Aterberg Classification system, and write the formula for determining the plastic index and the shrinkage index.

6. The student will be able to list four grain size classification systems, identify their users, and explain the merits of each.

Unit 4.00 Methods for Improving Soils (4 hours)

1. The student upon completion of this unit will be able to define the terms compaction and stabilization.

2. The student will be able to list and identify the operating procedure for 7 of a possible 10 pieces of compaction equipment.

3. The student will be able to define chemical stabilization, and be able to list by name 3 of the 5 chemical stabilizers and their uses.

Unit 5.00 Foundations (10 hours)

When the student completes this unit, he will be able to:

1. Sketch three types of footings, label them, and identify their use.

2. Calculate the resultant pressures on footings when given the total loads per square foot for a particular building type and occupancy.

3. Size footings when given loadings and allowable soil pressures.

4. Determine the allowable soil pressures when given major classifications of soils.

5. Define the two major classifications of piles.

6. Sketch and explain the action of end bearing, friction, and combination piles.

7. When given the commonly used pile types and loading ranges, to properly match the same.

8. Sketch the relative size and shape of at least three typical pile caps, and explain their function.

9. Identify the operating characteristics, advantages and uses of four of the six pile hammers previously discussed and explained.

10. Determine the length of piling required when given the formula, the diameter of the pile, the working load, and the factor of safety.

11. Match the definitions with the terms: loading test, driving resistance, safe working load, Hiley formula, the ENR formula, group action, and drag down.

12. Describe drilled-in and belled caissons through sketches and labeling.

13. Calculate the required socket depth when given the formula, the caisson diameter, type of soil, working skin friction, and safe working load.

Unit 6.00 Pavements and Subgrades (4 hours)

When the student completes this unit, he will be able to:

1. Identify the types of loads, the stresses in pavements, and list the advantages and uses of flexible and rigid pavements.

2. Make the necessary tests for subgrade investigation, record the information, determine the classification of the soil, and make a judgement decision on the allowable load.

3. Explain in writing the effects of subgrade movements.

4. Sketch and label typical cross sections of rigid and flexible highway pavements, airport runways, and taxiways.

5. Write the procedures and uses of the tests performed in evaluating the output of an asphalt plant, when given the ASTM designation and title.

Unit 7.00 Retaining Walls (10 hours)

Upon completion of this unit, the student will be able to:

1. Sketch and list the types of movements of slopes and embankments.

2. Identify the features of rotational and translatory slides.

3. Explain in writing pore water effects and stabilization measures.

4. Draw a sketch of a gravity wall, label the parts, and calculate the forces when given the loads and dimensions.

5. Calculate the resultants of fluid pressures on a wall by the use of the normal unit pressure method or the wedge method, when given the dimensions and the type of liquid.

6. Calculate the earth pressures on a wall when given the loads, dimensions, and type of soils.

7. Calculate the magnitude and location of the resultant of all forces on a gravity wall when given the loads and dimensions.

8. Determine the stability of a gravity wall when given the dimensions and loads.

9. Calculate the factor of safety against overturning for a gravity wall when given the dimensions and loads.

4.00 TOPICAL OUTLINE

Lecture, Demonstration and Recitation

1.00 Introduction — 2 hours

- 1.10 Definition of soil
- 1.20 Soil as a construction material
- 1.30 Importance of coordination of theory & practice
- 1.40 Soil formation and distribution
  - 1.41 Origin and composition
  - 1.42 Physical and chemical degradation
  - 1.43 Transportation of soil materials
    - Water
    - Glaciers
    - Wind
    - Combined actions

2.00 Field Investigations and Sampling — 4 hours

- 2.10 Factors affecting scope and extent
- 2.20 Methods of exploration depends upon:
  - 2.21 Type of exploration - preliminary - design purposes
  - 2.22 Extent of the survey - surface soils - deep strata
  - 2.23 Area covered by the survey
  - 2.24 Type of information wanted
  - 2.25 Nature of the soil deposit
  - 2.26 Equipment available
- 2.30 Surface exploration
- 2.40 Sub-surface exploration
  - 2.41 Preliminary
  - 2.42 Design purpose
  - 2.43 Methods of underground exploration
    - 2.431 Wash borings
    - 2.432 Dry sample borings
    - 2.433 Undisturbed sampling
    - 2.434 Auger boring
    - 2.435 Well drilling
    - 2.436 Rotary drilling
    - 2.437 Core borings
    - 2.438 Test pits

2.44 Borings

2.441 Location of borings for small projects
2.442 Location of borings for projects covering large area
2.443 Details of borings
2.444 Care of samples
2.445 Ground-water table
2.446 Borings for heavy structures
2.447 Soil samples - disturbed & undisturbed

3.00 Characteristics and Classifications of Soils 6 hours

3.10 Physical properties of soils

3.11 Simple soil properties

3.111 Volume ratios
Porosity
Void ratio
Degree of saturation

3.112 Water content
Gravitational
Capillary
Hygroscopi

3.113 Unit weight
3.114 Specific gravity
3.115 Density
Dry density
Wet density
Relative density

3.116 Angle of internal friction
Friction angle
Angle of repose

3.117 Cohesion
3.118 Plasticity
3.119 Consistency

3.12 Homogeneity and the variable nature of soils

3.121 Scattering
3.122 Statistical averages

3.13 Horizontal variation

3.20 Classifications

3.21 Preliminary classifications by soil types

3.211 Sand, gravel, and boulders
3.212 Silts
3.213 Clays
3.214 Peat
3.215 Hardpan
3.216 Loess
3.217 Shale
3.218 Topsoil
3.219 Fill

3.22 Sedimentary soil classification by structure

3.221 Single grained structure
3.222 Honeycomb structure
3.223 Flocculent structure
3.244 Mixed structure

3.23 Field method for identification of soil textures
3.24 Atterberg limits and indices
3.25 Grain-size classification

3.251 MIT
3.252 U.S. Bureau of Soils - triangular
3.253 American Society of Engineering Education
Gravel
Sand
Silt
Clay

3.26 Grading of soil

3.30 Permeability

3.31 Effects of pore water on soil properties
3.32 Darcy's Law

3.321 Laminar flow
3.322 Turbulent flow
3.323 Lower critical velocity
3.324 Reynolds number

3.40 Capillarity

3.41 Surface tension
3.42 Capillary fringe
3.43 Capillary forces and their effects

3.50 Seepage

3.51 Types of pressures

3.511 Effective pressure
3.512 Neutral pressure
3.513 Seepage pressure

3.52 Seepage forces
3.53 Quicksand conditions
3.54 Flow nets

3.541 Importance of flow nets
3.542 Sketching flow nets
3.543 Seepage tanks

3.60 Settlements

3.61 Importance of settlements
3.62 Effects of the rigidity of a structure
3.63 Effects of horizontal drainage

3.70 Shear strength

3.71 Strength theory

3.711 Friction between solid bodies
Friction angle
Angle of internal friction
Coefficient of Friction
Principal plane
3.712 Angle of obliquity

3.72 Shearing characteristics of sands
3.73 Shearing characteristics of cohesive soils

4.00 Improvement of Soils 4 hours

4.10 Compaction

4.11 Stress-strain-time relationships
4.12 Compressibility of soils

4.121 Sands
4.122 Clays

4.13 Consolidation

4.131 Characteristics
4.132 Swelling
4.133 Clays

4.20 Stabilization

4.21 Background information
4.22 Subgrade and shoulder
4.23 Grouting
4.24 Bentonite

5.00 Foundations — 10 hours

5.10 Footings

5.11 Individual-square-rectangle
5.12 Strip
5.13 Combined
5.20 Resultant of loads
5.30 Evaluation of soil pressures
5.40 Pile

5.41 Uses
5.42 Classification

5.421 Timber
5.422 Concrete
5.423 Steel
5.424 Combination

5.43 Types

5.431 Friction
5.432 Bearing
5.433 Combination

5.44 Evaluation of loads

5.50 Caissons

5.51 Uses
5.52 Major types
5.53 Construction
5.54 Design and use of belled
5.55 Design and use of drilled-in

6.00 Pavements and Subgrades — 4 hours

6.10 Pavements

6.11 Types and wheel loads
6.12 Stresses - flexible and rigid
6.13 Bituminous surfaces

6.14 Flexible airport pavements
6.15 Construction of flexible and rigid

6.151 Construction techniques and details
6.152 Handling traffic during construction
6.153 Safety
6.154 Supervision
6.155 Control of materials

6.20 Subgrades

6.21 Investigation
6.22 Classification of soils
6.23 Important properties
6.24 Tests
6.25 Effects of subgrade movements
6.26 Preparation and stabilization
6.27 Problems of construction
6.28 Granular bases and subbases

7.00 Retaining Walls 10 hours

7.10 Slopes and embankments

7.11 Types and movements
7.12 Rotational slides
7.13 Translatory slides
7.14 Pore water effects
7.15 Flow slides
7.16 Stabilization measures
7.17 Embankments

7.20 Retaining walls

7.21 Types and uses
7.22 Nomenclature
7.23 Resultants of fluid pressures

7.231 Normal unit pressures
7.232 Wedge method

7.24 Earth pressures
7.25 Resultant of all forces
7.26 Stability

7.261 Sliding
7.262 Overturning or rotation
7.263 Crushing or cracking

7.27 Factory of safety

5.00 METHODOLOGY

5.10 Teaching Procedures

Emphasis in this course is on fundamentals, a basic understanding of each topic or area, the reason why things are done, and concentration on how things are done.

The materials in this syllabus have been developed and organized to provide some technical competence as well as the skills and techniques required of civil technicians.

The course is taugh through lectures, seminar/recitations, demonstrations, and field or laboratory projects. Evaluation as an aid to the student (and the instructor) is evidenced by frequent quizzes and tests.

Although laboratory experiments (tests) are done on a small group basis, each student is required to record the data, perform the calculations, write the report, and make his calculations.

The instructor should review each lesson plan and related laboratory assignment to provide proper correlation between theory and application. Lectures and demonstrations are related to the practical application, which the student will experience in performing the required tests. The students' assignment sheets indicate this relationship.

The instructor will make certain that the required samples are available and that the necessary laboratory equipment is in proper working order *before* the scheduled lab session.

5.20 Texts

Basic Soils Engineering
Hough, B.K.
New York: The Roland Press, 1969

Building Construction Handbook
Merritt, Frederick S.
New York: McGraw-Hill Book Co.,Inc. 1965

Foundations of Structures
Dunham, Clarence W.
New York: McGraw-Hill Book Co., Inc. 1962

Highway Engineering
Ritter, Leo J. and Paquette, Radnar J.
New York: The Roland Press, 1960

Introductory Soil Mechanics & Foundations
Sowers, G.B. and Sowers, G.F.
New York: MacMillan Co., 1961

Introductory Soil Testing
Bauer, E.E. and Thornburn, T.H.
Champaign: Stipes Publishing Co., 1962

Procedures For Testing Soils
American Society for Testing and Materials
Baltimore: 1964

Soil Engineering
Spangler, Grant M.
Scranton: International Textbook Co., 1960

5.30 Periodicals

Civil Engineering Magazine (monthly)
New York: Rumford Press

Constructioneer (bi-weekly)
Hanover: Reports Corporation

Construction Methods and Equipment (monthly)
New York: McGraw-Hill, Inc.

Engineering News Record (weekly)
New York: McGraw-Hill, Inc.

5.40 Audio-Visuals and Equipment

Sound filmstrips and manuals by Soiltest Inc.,
2205 Lee Street
Evanston, Illinois

F-102 Unconfined Compression Test of Cohesive Soils

F-105 Moisture Content Determination of Soils

F-108 Test for Moisture - Density Relations of Soils

F-114 Test for Liquid Limit of Soils

F-132 Test for Density of Soil in Place

Sound films, available for rental charge of $5.00 per week from
Portland Cement Association
Old Orchard Road
Skokie, Illinois 60076

PC 108 Loads on Underground Conduits, 10 mins.

PC 111 Sewer Construction, 18½ mins.

PC 112 Soil Cement Slops Protection for Earth Dams, 22 mins.

PC 046 Soil-Cement Inspection and Field Control, 17 mins.

PC 051 Standard Laboratory Controls for Soil-Cement Mixtures, 20 mins.

16 mm. sound motion picture projector
Filmstrip protector
Soil testing lab equipment
Wall-mounted slide rule
Flip chart
Overhead projector

5.50 Instructor's Preparation

The instructor, at the first class session, will present an overview of the course, explain what is expected and required of the student, how the student's progress will be measured, and explain the correlation between lecture and laboratory plus distribute the two assignment sheets.

A lesson plan is prepared for each class meeting and includes the behavioral objective, the topic, methodology, aids, and subject outline. The instructor reviews the plan -- modifies for current developments -- scans the reading assignments, previews all required films, and checks operational status of equipment. A sub summary is prepared and presented at the conclusion of each lesson, and a major summary for each teaching unit.

6.00 STUDENT ACTIVITIES

All students are required to have their own texts, a notebook, a slide rule, and necessary laboratory report forms. Assignment sheets -- distributed to each student -- detail the reading assignments and laboratory assignments for each class meeting.

The student is required to attend all class sessions, unless prior approval has been obtained from the instructor. An absence does not excuse the student from performance of the work assigned.

The care and maintenance of laboratory equipment is the personal responsibility of each student. On a rotating basis, every lab group will assign a chief, whose responsibility will be to see that the equipment is returned to the proper storage cabinet in a condition at least equal to that in which it was received.

Students' performance (hence grade for the course) will be determined by the instructor based on attendance, class participation, attitude, test grades, and laboratory results.

Student's Material

Texts

Soil Testing for Engineers
Lambe, T. William
New York: John Wiley & Sons, Inc., 1965

PCA Soil Primer
Portland Cement Association
Skokie: Portland Cement Association, 1962

Misc.

Slide rule
Notebook
Lab test data sheets

6.10 Student Lecture Assignment Sheet

Text:

(A) *Soil Testing for Engineers*
Lambe, T. William
New York: John Wiley & Sons, Inc.

(B) *PCA Soil Primer*
Portland Cement Association
Skokie, Illinois: Portland Cement Association

Class Mtgs.	Unit	Topic	Reading Assignment	Lab	Week
1 & 2	1.00	Introduction	(A) Nomenclature & Chapter I	1.00	1
3-6	2.00	Field Investigation & Sampling	(B) Chaps. 4 & 5	2.00	2
7.12	3.00	Characteristics & Classifications of Soils	(B) Chaps. 1 & 2	Test	3
13-16	4.00	Improvement of Soils	(B) Chap 3, p. 29-31 & 35-37	3.00	4
17		Test			
18-27	5.00	Foundations	Handouts	4.00	5
				Test	6
				5.00	7
28-30	Mid-Quarter Examination		All previous	--	8
31-34	6.00	Pavements & Subgrades	(B) Chap. 3	6.00	9
35-44	7.00	Retaining Walls	Handouts	7.00	10
				Final	11
45	Final Examination				12

6.20 Laboratory Reading Assignment

Week	Lab		Assignment
1	1.00	General Laboratory Instructions	Handouts
2	2.00	Density of Soil in Place	Handouts
3		Test	
4	3.00	Grainsize Analysis	(A) Chap. IV
5	4.00	Moisture Density	(A) Chap. V
6		Test	
7	5.00	Moisture Content	(A) Chap I. p. 8-14
8		Mid-Term	All previous
9	6.00	Unconfined Compressive Strength	(A) Chap. XII
10	7.00	Liquid Limit of Soils	(A) Chap. III

7.00 EVALUATIONS

The evaluation of the students' performance in this course is a composite of several factors. These factors consist of the grades earned on quizzes, tests, mid-terms, and final examinations, laboratory experiments, attendance, class participation, and professional attitude.

This is a core area subject for all Civil Technology students; therefore, as in all classes, an attempt is made to motivate them to do outstanding work -- at least a "C" (70%) or better. A final grade of "D" (60%) is required to pass the course.

7.10 Testing

Progress performance is accomplished through a series of quizzes, tests, and examinations, both for the lecture and the laboratory sessions. The half-hour quizzes are usually unannounced; however, tests and examinations are scheduled well in advance. An overall mid-term grade is established after the mid-term examination. Each student is advised of his grade in a private conference, counseled as to what is required to improve the grade, and what action he must take to accomplish this. He is also told that if no change is made in his future performance, his final course grade will not be any higher than the mid-term grade.

7.20 Laboratory Testing

The laboratory testing, which the student performs is identical to the tests of the Standard American Society for Testing Materials.

Therefore, the skills and techniques developed are directly transferrable to career situations. Because of this the student operates in a small group in the laboratory and is under constant supervision to help in developing the proficiency demanded under job conditions. Each week an appraisal is made of the student's progress in lab technique, the results of his tests, and more importantly the judgment decisions made based on his results. Two lab tests and a final examination are included as part of the evaluation of lab work.

8.00 LABORATORY EXPERIMENTS (ASTM TESTS)

8.10 Soil Laboratory Experiment Schedule

Experiment	Subject	Hours
1.00	General Laboratory Instructions	3
2.00	Density of Soil in Place by the Sand Cone Method ASTM D1556-64T	3
3.00	Grain Size Analysis ASTM D422-63	3
4.00	Test for Moisture-Density Relations of Soils - Standard Compaction ASTM D698-58T	3
5.00	Moisture Content Determination of Soils ASTM D2216-63T	3
6.00	Unconfined Compression Test of Cohesive Soils ASTM D2166-63T	3
7.00	Test for Liquid Limit of Soils ASTM D423-61T	3

8.20 Lab Experiment No. 1.00
Soils and Foundations (CT 523)

Title:	Equipment & Procedure Familiarization for Soil Testing
Standard designation:	None
Purpose:	To acquaint the student with the equipment available and utilized for soil testing; to present the purpose and procedures for the various tests; and to explain the degree of accuracy expected.
Objective:	Upon completion of this experiment the student when shown either the actual equipment or a sketch of the equipment will be able to identify it by the proper name and explain its use.
Size of lab party:	Entire class (maximum 15 to 20)
Equipment:	Standard soil testing equipment
Procedures:	Equipment is arranged on tables in groups according to experiment usage, and class will rotate in the "country fair teaching method."

8.30 Lab Experiment No. 2.00
Soils and Foundations (CT 523)

Title:	Test for Density of Soil in Place by the Sand Cone Method
Standard designation:	ASTM D-1556-64T and AASHO T-191-61
Purpose:	To determine the in-place density of soils.
Objective:	Upon completion of this experiment the student will be able to: 1. Follow the correct procedure and utilize the proper equipment in accordance with the ASTM specification. 2. Determine and accurately record the required data. 3. Calculate the in-place dry density of the material tested.
Size of lab party:	3 to 5
Equipment:	Density apparatus, sand, balances (0.1 of 1.0 g. sensitivity), drying oven, small pick, drying pan, thermometer, paint brush, slide rule, and notebook.
References:	Sound filmstrip and manual *Test For Density of Soil in Place by the Sand Cone Method* Soiltest, Inc. Evanston, Illinois *Density of Soil in Place by the Sand Cone Method* Pages 418-422 'Procedure for Testing Soils' American Society for Testing and Materials, Philadelphia, Pennsylvania, December 1969
Procedure synopsis:	1. Determine volume of jar and attachment; weight and record the weight. 2. Determine the bulk density of sand. 3. Determine the weight of sand required to fill the funnel.

4. Determine the density of the soil in place.

5. Calculate the volume of the density apparatus.

6. Calculate the bulk density of the sand.

7. Calculate the moisture content and dry weight of material.

8. Calculate the in-place dry density of the material.

8.40 Lab Experiment No. 3.00
Soils and Foundations (CT 523)

Title:	Grain-Size Analysis of Soils
Standard designation:	ASTM D422-63
Purpose:	The quantitative determination of the distribution of particle sizes in soils.
Objective:	Upon completion of this experiment, the student when given a soil sample will be able to: 1. Determine the distribution of particle sizes larger than ¼" (by sieving) and smaller than ¼" by using a sedimentation process. 2. Report in tabular form (AASHO T88-49) the mechanical analysis data. 3. Plot a grain size distribution curve. 4. From the data select the proper soil classification.
Size of lab party:	3 to 5
Equipment:	For sieve analysis -- set of sieves, a sieve shaker, brush (for cleaning sieves), beam balance (0.1 g. sensitivity), drying oven, a desiccator, a syringe, large pan, and a mortar and rubber tipped pestle. For hydrometer analysis -- hydrometer, mixer, deflocculating agent, two graduated cylinders (1 liter), distilled water supply, balance (0.1 g. sensitivity), drying oven, desiccator, thermometer (0.1°C), syringe, large evaporating dishes, spatula, and a timer.
References:	*Grain-Size Analysis of Soils* Page 95-106, Procedure for Testing Soils, American Society for Testing and Materials, Philadelphia: December 1964 *Soil Testing for Engineers* Lambe, William T., page 29-42 New York: John Wiley & Sons, 1965

Procedure synopsis:

Sieve analysis:

1. Weigh each clean sieve to 0.1 g.
2. Weigh the 500 g. speciman to 0.1 g.
3. Sieve the soil.
4. Weigh each sieve and pan with the soil retained on them to 0.1 g.
5. Determine the weights of soil retained.
6. Calculate the percentages retained on each sieve and pan.

Hydrometer analysis:

1. Mix a moist 50 g. dry weight sample.
2. Add the deflocculating agent to the paste and mix the suspension in a machine.
3. Wash the suspension into a graduated cylinder and increase volume to 1000 cc.; thoroughly mix by shaking for 30 seconds.
4. Insert the hydrometer and start timer.
5. Record readings for three separate tests, at 1/4, 1/2 and 1 and 2 minutes; and 2, 5, 10 and 20 minutes.
6. Determine the dry weight of the sample.

Present the results of the two analyses in the form of a distribution curve. Read from the curve the necessary information for calculating the uniformity coefficient.

8.50 Lab Experiment No. 4.00
Soils and Foundations (CT 523)

Title:	Test for Moisture-Density Relations of Soils-Standard Compaction.
Standard designation:	ASTM D-698-58T & AASHO T-99-57
Purpose:	To determine the relationship between the moisture content and density of soils when compacted in a mold of a given size.
Objective:	The student upon completing this experiment when given a soil sample will be able to: 1. Determine the date for making the calculations. 2. Calculate the moisture content and the dry unit weight of the sample. 3. Plot a moisture density curve. 4. Select from the curve the weights per cubic foot for various percentages of saturation.
Size of party:	3 to 5
Equipment:	Compaction device, moisture sprayer, No. 4 sieve, rubber-tipped pestle, scoop, straight edge and knife, large mixing pan, balances (0.01 lb. sensitivity and 0.01 g. sensitivity), drying oven, desiccator and, drying cans.
References:	Sound filmstrip and manual *Test for Moisture-Density Relations of Soils* Soiltest, Inc., Evanston, Illinois *Soil Testing for Engineers* Lambe, William T., p. 43-51 New York: John Wiley & Sons, 1965 *Moisture Density Relations of Soils* p. 114-119, Procedure for Testing Soils, American Society for Testing and Materials, Philadelphia: December 1964.
Procedure synopsis:	1. Prepare damp sample and form in mold. 2. Compact sample in approved manner. 3. Weigh and determine wet unit weight. 4. Determine moisture content from a representative slice of sample. 5. Calculate the moisture content and dry weight. 6. Plot density-moisture content curve.

8.60 Lab Experiment No. 5.00
Soils and Foundations (CT 523)

Title:	Laboratory Determination of Moisture Content of Soil
Standard designation:	ASTM D2216-63T
Purpose:	To determine the moisture or water content of a soil as a ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the solid particles.
Objective:	Upon completion of this experiment, the student when given a soil sample will be able to: 1. Use the standard procedure and determine the amount of moisture in the sample. 2. Calculate the moisture content ratio.
Size of lab party:	3 to 5
Equipment:	Drying oven, a balance, and suitable containers resistant to corrosion.
References:	Sound filmstrip and manual *Moisture Content Determination of Soils* Soiltest, Inc., Evanston, Illinois *Soil Testing for Engineers* Lambe, William T. p. 8-12 New York: John Wiley & Sons, 1965 *Laboratory Determination of Moisture Content of Soil* "Procedure for Testing Soils" p. 107-108 Society for Testing and Materials, Philadelphia: December, 1964
Procedure synopsis:	1. Select sample size in accordance with specification. 2. Weight a clean, dry, container and lid. 3. Add sample to container and re-weigh. 4. Place container and sample (lid removed) in oven. 5. Maintain temperature (230± 9F or 110± 5C) and dry sample to a constant weight. 6. Remove container from oven, replace lid, and cool to room temperature. 7. Weigh lid, container, and dry sample. 8. Calculate the moisture content of the soil.

8.70 Lab Experiment No. 600
Soils and Foundations (CT 523)

Title:	Unconfined Compressive Strength of Cohesive Soil
Standard designation:	ASTM D2166-63T
Purpose:	To obtain, quickly, approximate quantitative values of the compressive strength of soil possessing sufficient coherence to permit testing in the unconfined state.
Objective:	Upon completion of this experiment the student, when given a soil sample, will be able to follow the proper procedure for obtaining the required data and to write a report that will include: (a) unconfined compressive strength (b) type and shape of specimen (c) height-to-diameter ratio (d) visual description (e) initial density, moisture, and degree of saturation (f) average strain at failure (g) remarks noting any unusual conditions or other data that would be considered necessary to properly interpret the results obtained.
Size of lab party:	3 to 5
Equipment:	Unconfined compression device, specimen trimmer with accessories, remolding cylinder and plunger membrane for remolding, balances (0.01 g. and 0.1 g. sensitivity), drying oven, desiccator, timer, watch glass, scale, protractor, spatula, evaporating dish, and wax paper.
References:	Sound filmstrip and manual *Unconfined Compression Test of Cohesive Soil F-102* Soiltest, Inc., Evanston, Illinois *Soil Testing for Engineers* Lambe, William T., p. 110-119 New York: John Wiley & Sons, 1965 *Unconfined Compressive Strength of Cohesive Soil* "Procedures for Testing Soils," p. 252-255, American Society for Testing and Materials, Philadelphia: December 1964

Procedure synopsis:

1. Accurately trim an undisturbed sample to proper size.
2. Measure and record dimensions to nearest 0.01 in.
3. Place specimen in testing machine.
4. Record initial readings on the proving ring dial, timer, and vertical deflection dial.
5. Start compression, recording deflections every 0.01 in. at start, then every 0.02 in., and 0.05 in. as stress strain curve begins to flatten.
6. Compress specimen until cracks have definitely developed.
7. Carefully sketch the crack failure pattern, and measure the angle of the failure plane with the horizontal.
8. Draw the stress-strain curve.
9. Determine the water content from three representative samples.

8.80 Lab Experiment No. 7.00
Soil and Foundations (CT 523)

Title:	Liquid Limit of Soils
Standard designation:	ASTM D423-61T
Purpose:	To determine the liquid limit of a soil, which is the water content expressed as a percentage of the weight of the oven-dried soil, at the boundary between the liquid and plastic state.
Objective:	Upon completion of this experiment, the student will be able to conduct the experiment in accordance with this standard ASTM procedure, record the proper data, and make the necessary calculations for determining the liquid limit for the given soil sample.
Size of lab party:	3 to 5
Equipment:	Liquid limit device and grooving tool, shrinkage limit set, large glass plate, distilled water, balances (0.01 g sensitivity and 0.1 g. sensitivity), drying oven, desiccator, watch glasses, evaporating dishes, and spatula.
References:	Sound filmstrip and manual *Test for Liquid Limit of Soils* Soiltest, Inc., Evanston, Illinois *Soil Testing for Engineers* Lambe, William T. p. 22-28 New York: John Wiley & Sons, 1965 *Liquid Limit of Soils* Procedure for Testing Soils, American Society for Testing and Materials, December 1964
Procedure synopsis:	1. Mix the 100 g. sample to form a uniform paste. 2. Place portion of paste in cup; smooth and groove the surface. 3. Determine the number of blows to close groove. 4. Repeat for three separate samples. 5. Make four water content determinations. 6. Make a plot of water content against log of blows.

9.00 APPENDICES

A. 9.10 Sample Lesson Plan

B. 9.20 Sample Completion Test

C. 9.30 Sample True-False Test

D. 9.40 Sample Quiz

APPENDIX A

9.10 Sample Lesson Plan

Teaching Unit 1.00 — Introduction — 2 hours

Lesson 1 — 1 hour

Behavioral objective: When the student has concluded this lesson, he will be able to sketch a soil profile of the ages of soil and label the formation, explain the use of soil as a construction material, and how soils receive and distribute applied loads.

Method: Lecture and demonstration

Aids: Chalkboard, flip chart and samples

1.00 Introduction

1.10 Soils, soil mechanics and soil engineering

1.2 Job market, opportunities, requirements, and qualifications

1.3 Soil-solid mineral particles
Physical and chemical weathering
Moisture, organic matter, air, and other gases

1.4 Soil as a construction material
How loads are applied
How loads are dissipated
Texture
Shape
Gradation-voids-density
Moisture

2.00 Soils Engineering Practices

2.1 Site investigation

2.2 Structural foundations
Types
Settlements

2.3 Lateral earth pressures
2.4 Unretained earth slopes
2.5 Earthworks construction
2.6 Highway and airfield pavement design

3.00 Related Subjects

- 3.1 Geology
- 3.2 Pedology
- 3.3 Soils physics and chemistry
- 3.4 Civil engineering
- 3.5 Construction experience
- 3.6 Costs

4.00 Methods Used in Soil Engineering

- 4.1 Theory
- 4.2 Empirical
- 4.3 Analytical
- 4.4 Experimentation and testing
- 4.5 Combination

5.00 Summary of Lesson I

- 5.1 Introduction
- 5.2 Soils engineering practices
- 5.3 Related subjects
- 5.4 Methods

6.00 Preview of Lesson II — Soil Formation and Distribution

Texts: *Soil Testing for Engineers*
Lambe, William T.
New York: John Wiley & Sons, Inc.

Student's
Preparation: Read Chapter 1, bring notebook and slide rule to class.

Instructor's
Preparation: Review lesson plan and reading assignment; arrange for charts, samples and chalk.

APPENDIX B

9.20 Sample Completion Test

1. A soil which is composed primarily of particles of a single uniform size is referred to as a _____ material.

2. A soil which has uniform variation in particle size is know as a _____ material.

3. The ratio of the diameter at the 60 percent finer point to that at the 10 percent finer point on the gradation curve is _____.

4. The major classes in which soils may be grouped on the basis of texture are _____, _____, _____.

5. A soil in the loosest possible condition would have a relative density of _____ and in its densest condition _____.

6. As a soil in drying from the liquid state of consistency reaches a point at which it ceases to behave as a liquid and begins to acquire the properties of a plastic, it has reached its _____ limit.

7. The size of the smallest (square) opening through which a particle will pass is known as the _____.

8. The size at which 10 percent of all the particles are finer is the _____.

9. The particle diameter of a stone with the dimensions 8 x 4 x 2 mm is _____.

10. During a compression test, if the loading is removed, _____ occures next.

11. _____ particles are generally plate shaped.

12. A decrease in volume in response to static loading is termed _____ soil.

13. A decrease in volume in response to rolling or tamping is termed soil _____.

14. _____ water differs from adsorbed water only in that it is completely free to move through or drain from solid under the influence of _____.

15. An average value of the gradient may be obtained by dividing _____ lost between points by the total _____ between them.

APPENDIX C

9.30 Sample True False Test

1. The rate of flow of ground water is proportional to the gradient.

2. Air drying alone under standard conditions removes most of the capillary water in a soil sample.

3. Because of its immobility, gravitational water is closely related to absorbed water.

4. Laminar flow usually occurs in all types of clay.

5. Water at the phreatic surface is at atmospheric pressure.

6. Colloidal materials have particles of bulky shape.

7. A basic implication of the term single grain material is that there is virtually no effective combination of particles to form aggregates.

8. The terms mixed soil may be applied to any combination of the four main textural classes.

9. Virgin compression curves can be obtained only for undisturbed soil samples.

10. Soil formations which are believed to have been subjected at one time to greater loading than that which presently exists, are termed normally loaded.

11. In granular soils, vibration results in a decrease of the volume of solids.

12. The phreatic surface and the gound water table are one and the same.

13. Velocity head associated with seepage in ordinary soils is usually so small that it is completely negligible.

14. The permeability coefficient is inversely proportional to the rate of flow of water in a soil.

15. If a moisture content is reached at which shrinkage of the material ceases, this moisture content is the liquid limit.

16. Bulk specific gravity is the dry weight to superficial particle volume ratio divided by the density of water.

17. The terms specific gravity and absolute specific gravity may be used interchangeably.

APPENDIX D

9.40 Sample Quiz

A clay sample of 0.300 ft.^{3} has a total wet weight of 4.17 lbs. and a dry weight of 3.92 lbs.

1. What is its water content on a dry weight basis?
2. What is the degree of saturation of the clay if G = 2.75?